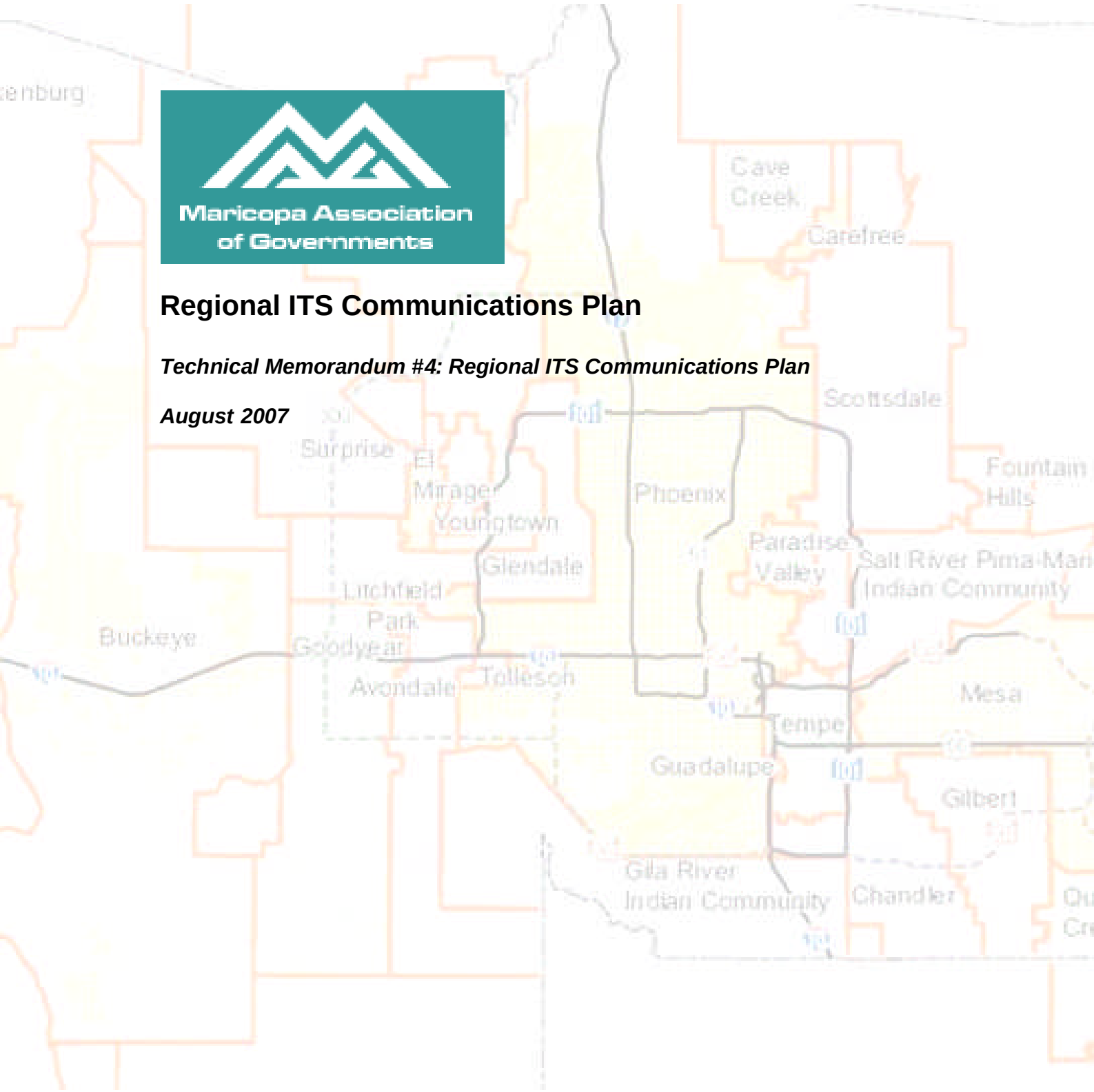

Maricopa Association of Governments

Regional ITS Communications Plan

Technical Memorandum #4: Regional ITS Communications Plan

August 2007

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1.0 Deployment Considerations

1.1 General Deployment Considerations

The most prudent solution to obtain a regional ITS network with adequate bandwidth to meet projected bandwidth needs for ITS interoperability is to utilize existing infrastructure including conduit and dark, single mode fiber. ADOT has deployed and plans to deploy single mode fiber that complies with recommended ring topology. A more in-depth study will be required to identify specifics of available infrastructure and to obtain jurisdictional owner's commitment to share available resources to support regional interoperability. This plan is based on the assumption that actual dark fiber can be made available or virtual fiber created through use of simple wave division multiplexing. Figure 1.1-1 presents a map illustrating the existing and planned ADOT fiber. The deployment schedule of conduit and fiber on Loops 101 and 202 as well as on the I-17 and I-10 extensions will dictate the schedule for implementation of the build out of the regional ITS communications network rings.

Figure 1.1-1: ADOT FMS Fiber Deployed and Planned to be Deployed
(Ref. MAG 2007 Regional Transportation Plan Update)

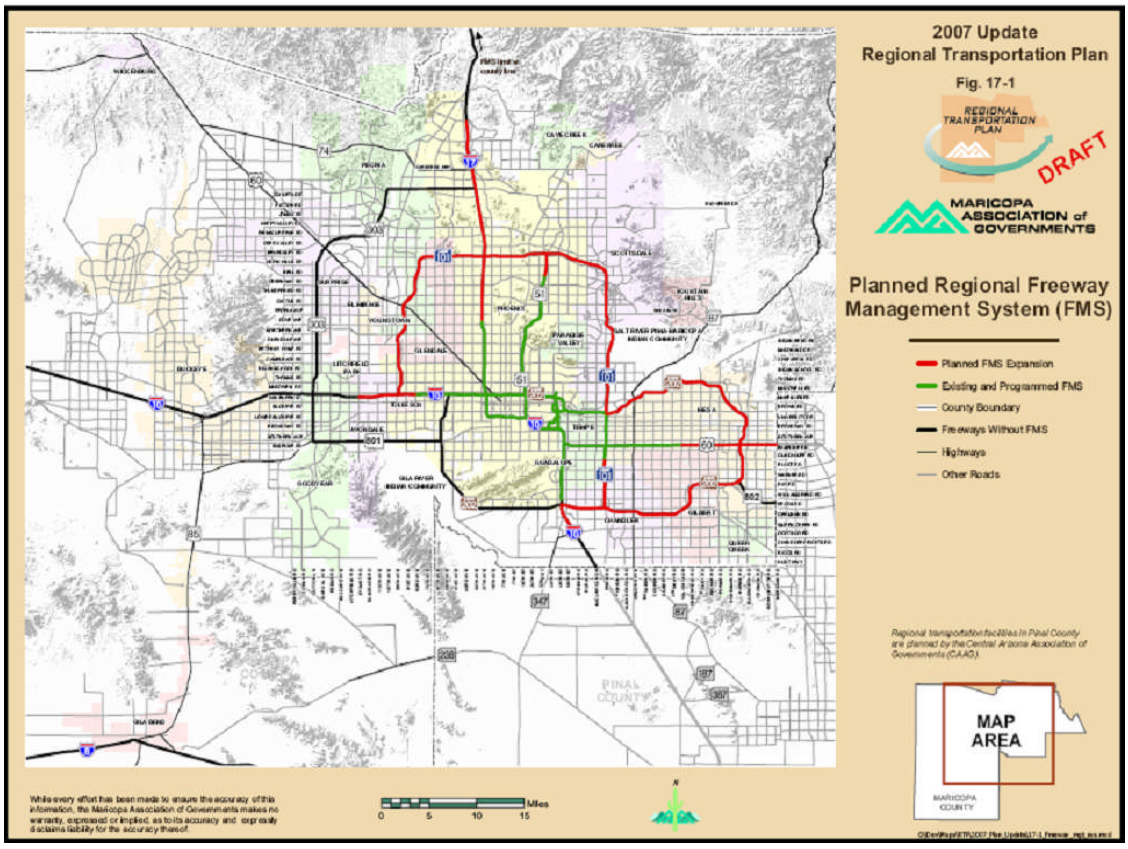
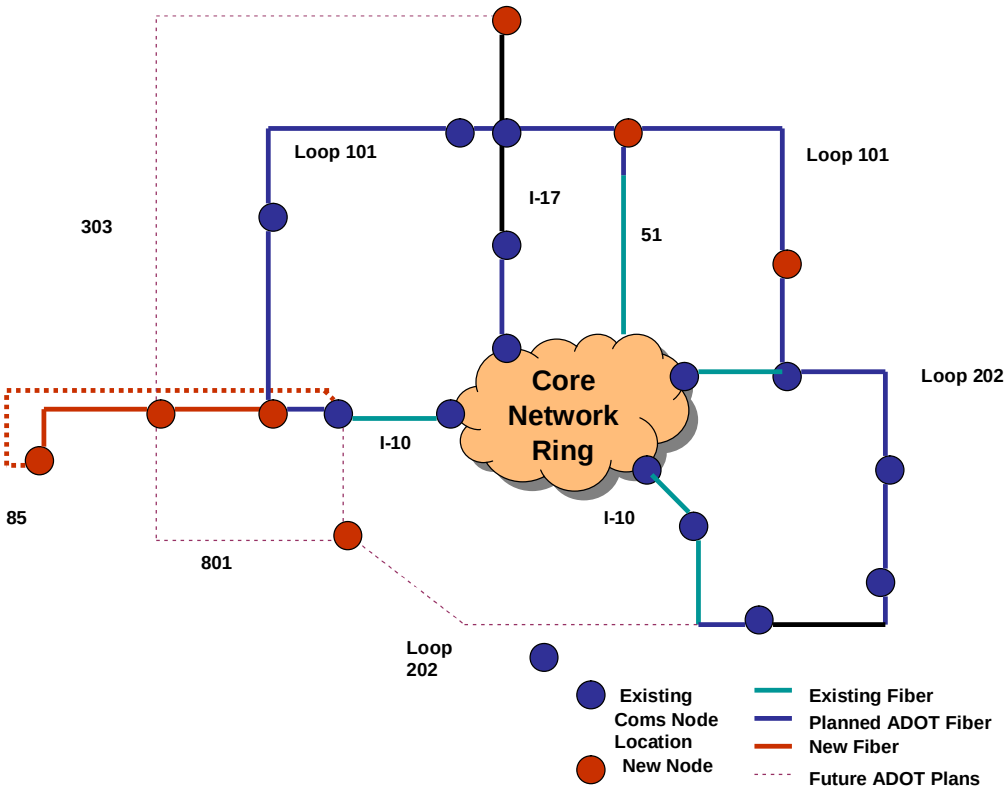


Figure 1.1-2 illustrates the ring topology recommended for the regional ITS network. The optical rings, for the most part, follow ADOT existing or planned fiber routes. There is a core ring forming the primary net and two subnets. Additional edge rings form small subnets, which operate at Gig-E data rates. The edge rings are utilized to interconnect jurisdictions that may be clustered and away from the backbone rings.

Figure 1.1-2: Ring Topology for Three-Ring Solution

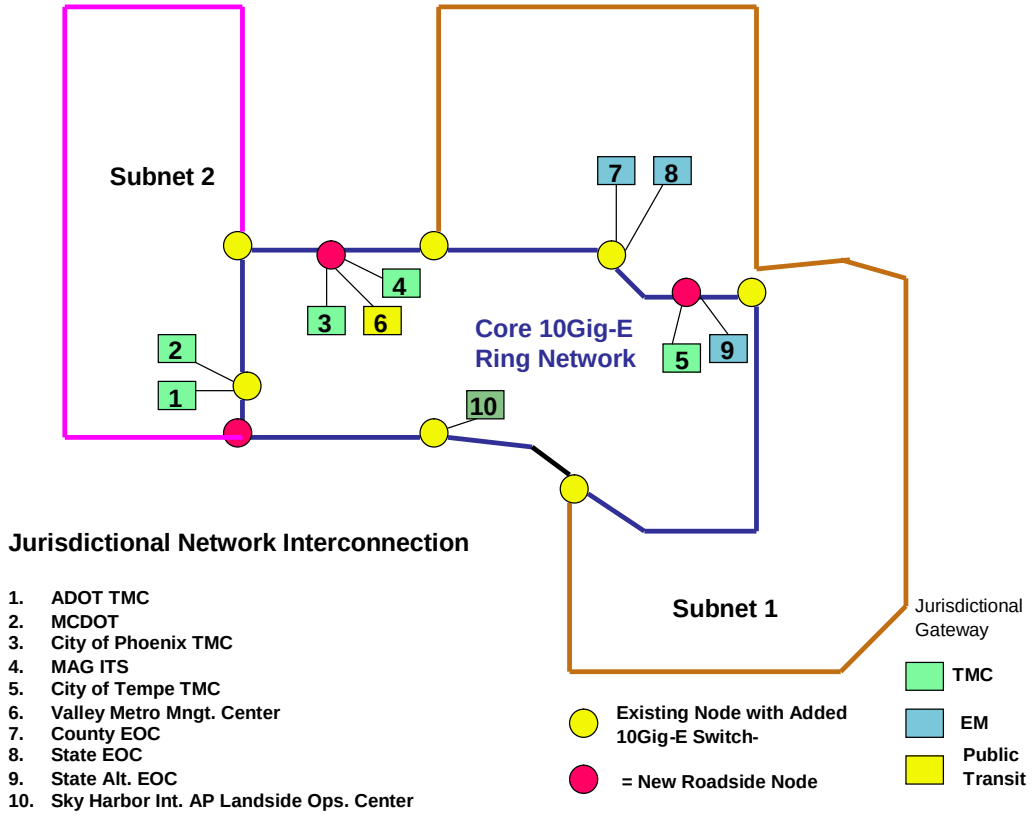


There is currently fiber deployed that can possibly support the deployment of a core ring. This construction can be initiated upon funding availability and upon concurrence from ADOT that fiber can be utilized. Subnet rings can be built out from the core ring in a phased approach.

1.2 Initial Deployment

Figure 1.2-1 presents the candidate core ring. Ring interworking nodes are illustrated as well as existing node locations and possible location of new nodes. Fiber must be accessible at splice closures or at fiber termination panels to support adding a new node. Existing node locations are illustrated and fiber should be accessible at these locations.

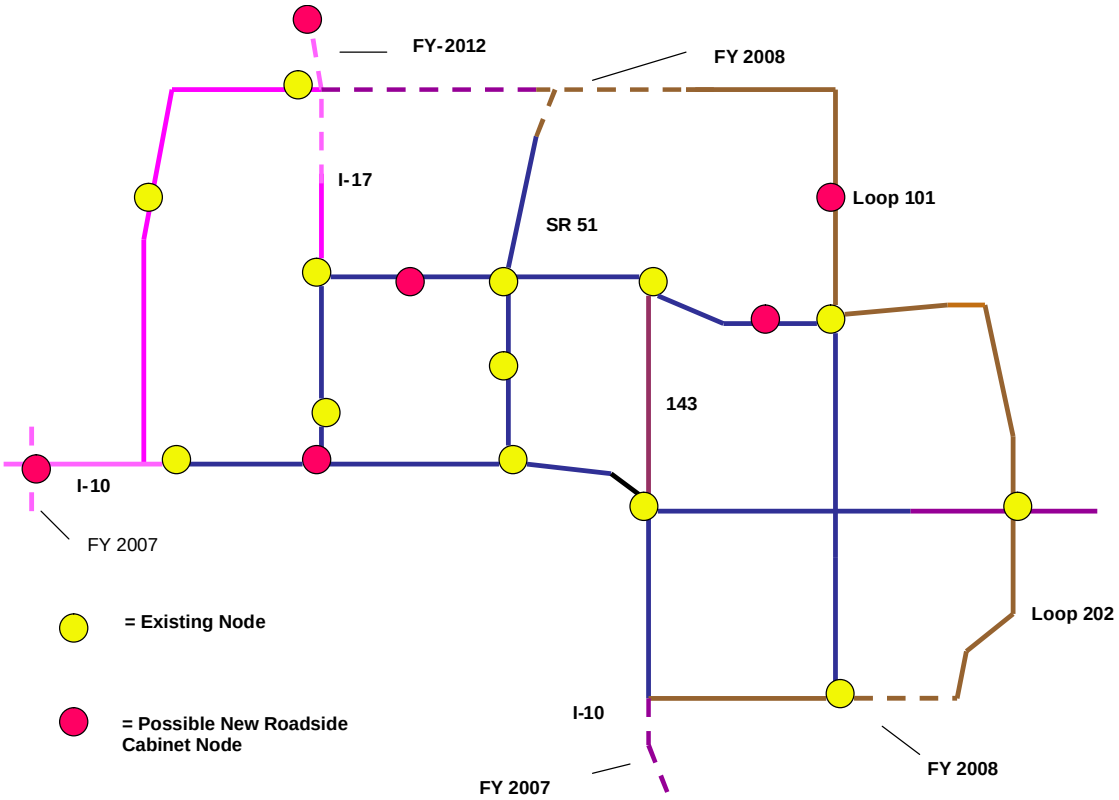
Figure 1.2-1: Core Ring Network



Color-coding of jurisdictional Gig-E gateways to the Regional ITS Network is based on population projections and associated transportation infrastructure growth. For the purpose of this plan, a jurisdiction with the population of 20,000 is considered to be a candidate for deploying a small ITS Center, which perhaps may even be co-located within the traffic engineer's office (or similar with EMS). Green indicates that the jurisdiction is projected to have significant ITS deployment based on 2030 MAG population projections. Figure 1.2-1 also illustrates planning locations for subnet ring interconnects with the core ring.

Figure 1.2-2 illustrates fiber deployment plans as available from funding information related to ADOT fiber. From reviewing figure 1.2-2, it can be concluded that the core network ring has potentially available fiber installed. In addition, it can be concluded that forming subnets will be post 2012, unless ADOT fiber deployment is accelerated.

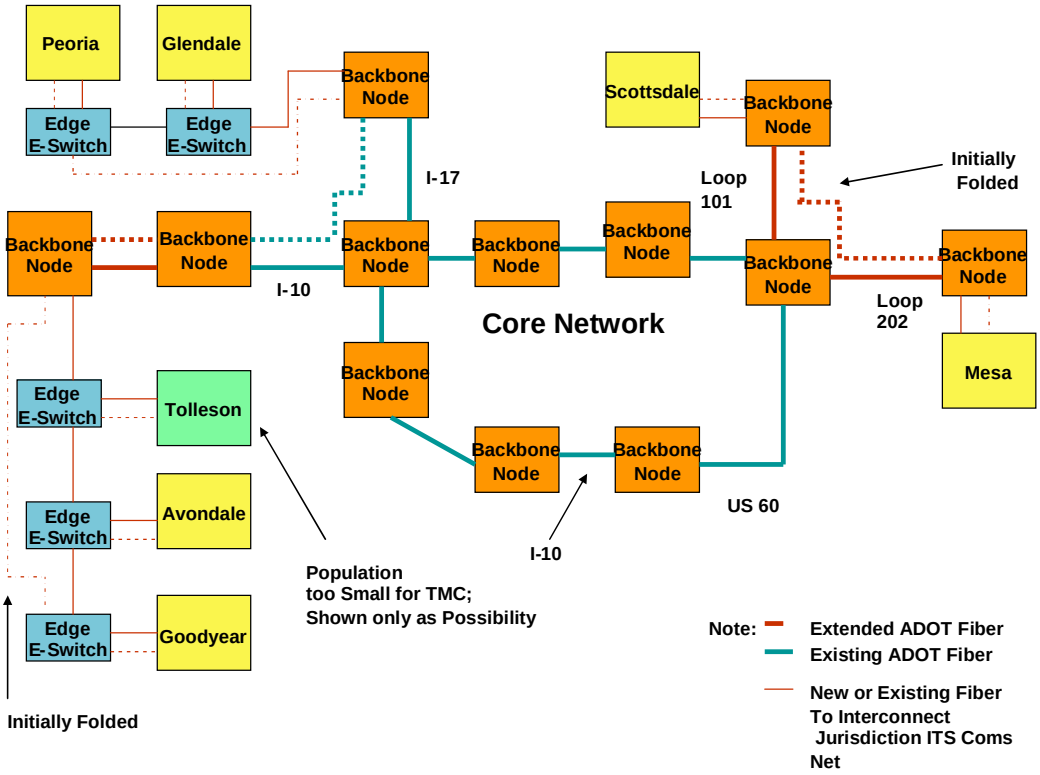
Figure 1.2-2: Potential Availability of ADOT Fiber
(Ref. ADOT Funding Plans; Dates Represent Start of Construction)



1.3 Phase 2 Deployment

Phase 1 deployment should be the core optical ring. Figure 1.3-1 illustrates a phase 2 deployment of folded rings to interconnect some of the major jurisdictions that have established ITS deployments. To accomplish this would require acceleration of fiber deployment along Loop 101 to facilitate interconnecting Scottsdale and extending fiber out I-10W facilitating interconnection of Avondale, Goodyear and Buckeye. Folded rings will be unfolded in future phases based on the deployment schedule of ADOT for fiber on the remaining sections of Loop 101 and Loop 202(SE). This will complete the core ring and two subnet rings. Jurisdictions would plan gateway interconnects based on scheduled completion of the supporting backbone rings and interconnect nodes.

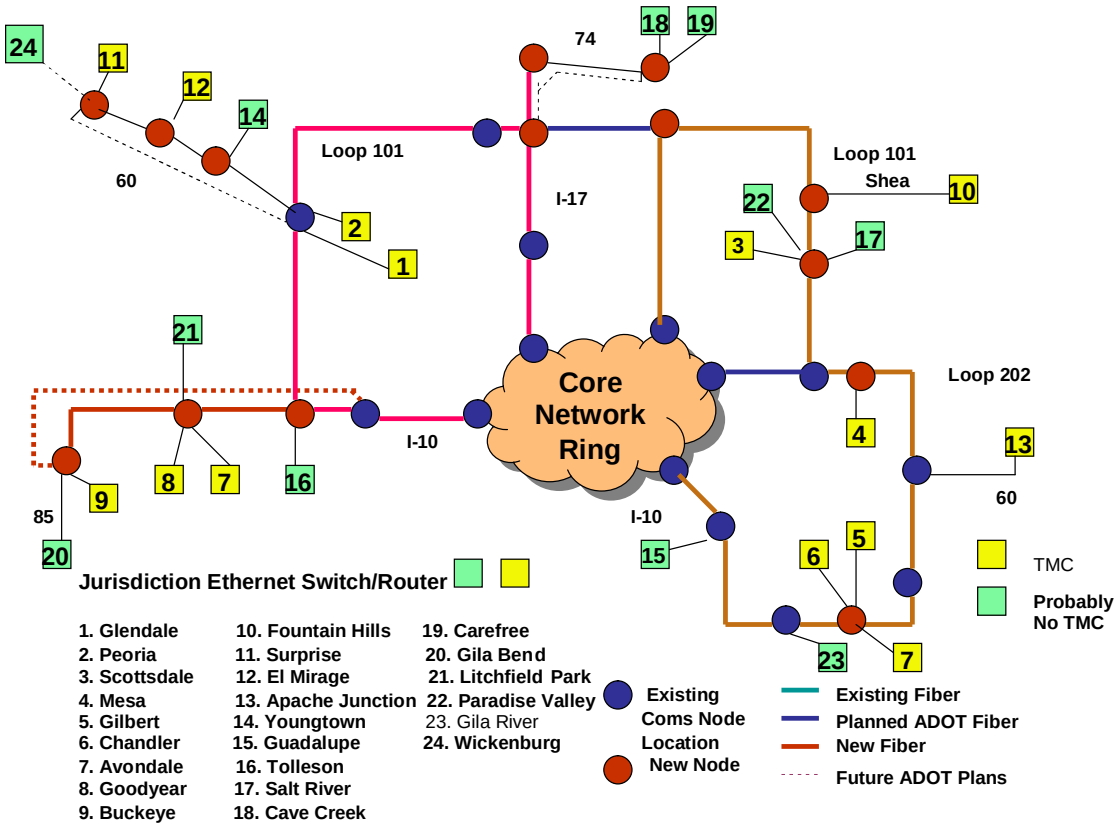
Figure 1.3-1: Phase 2 Deployment Using Folded Rings



1.4 Phase 3 Deployment

Phase 3 requires all fiber to have been deployed to complete the overall ring topology. Phase 3 most likely will be possible around 2015. Figure 1.4-1 illustrates the final configuration of the regional ITS network after completion of phase 3 deployment.

Figure 1.4-1: Regional ITS Network Configuration After Completion of Phase 3



1.5 Interconnections of Jurisdictional Networks and the Regional ITS Network

Figure 1.5-1 illustrates the interface between a jurisdictional network and the regional network. The link to the regional network will be Gig-E and the regional network will initially operate at 10Gig-E.

The regional network interconnect nodes will be at locations where fiber is accessible. This means that interconnect locations will be at existing ADOT communications node buildings (if possible) and/or at splice closures where fiber is accessible. At locations not having communications node buildings, the backbone 10Gig-E switch with Gig-E interface ports will be housed in an environmentalized cabinet. The backbone Ethernet Switch will be OSI Layer 3 compliant and should support EAPS (RFC 3619 - Ethernet Automatic Protection Switching), RADIUS (RFC 2138 - Basic RADIUS Operations; RFC 4675 - RADIUS Attributes for Virtual LAN and Priority Support; RFC 3162 - RADIUS and IPv6; and RFC 2866 - RADIUS Accounting) and IEEE802.1x, Port Based Network Access Control standard.

Figure 1.5-2 illustrates the additional electronic and fiber termination equipment that would be necessary in an existing node building. A separate fiber termination panel would be utilized to separate the two networks. Also, a separate UPS would be utilized, which could be monitored via network management element of the regional network. Figure 1.5-3 illustrates equipment associated with a roadside node (no node building)

Figure 1.5-1: Interconnect Diagram Between the Regional Network and a Jurisdictional Network

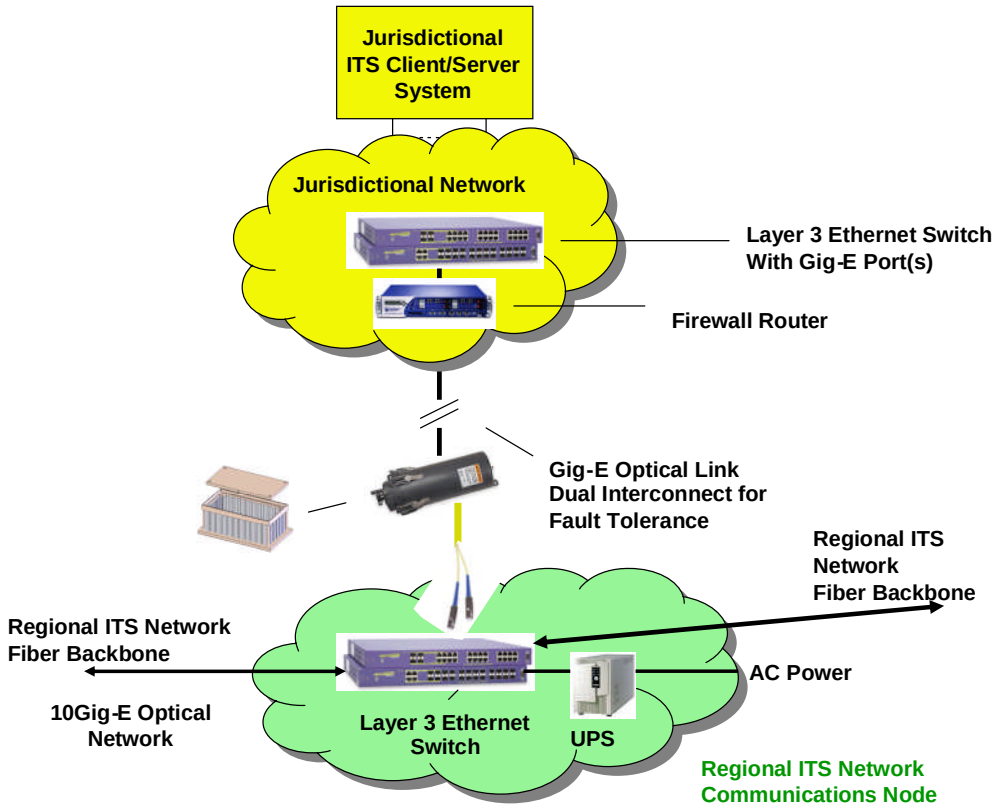


Figure 1.5-2: Example of Communications Node Building Additional Equipment to Support an Overlay Regional ITS Communications Network

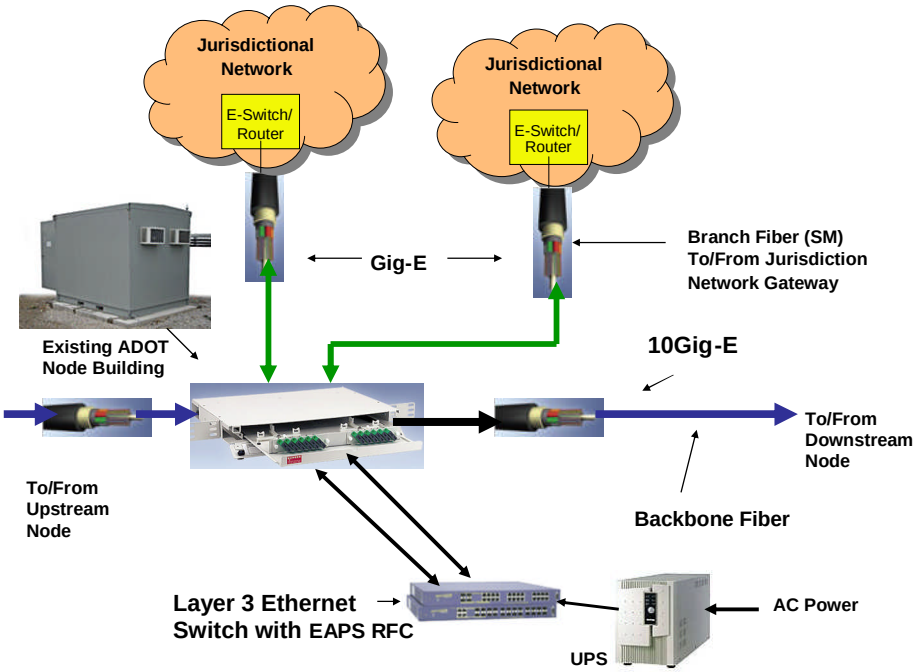


Figure 1.5-3: Roadside Regional Network Node

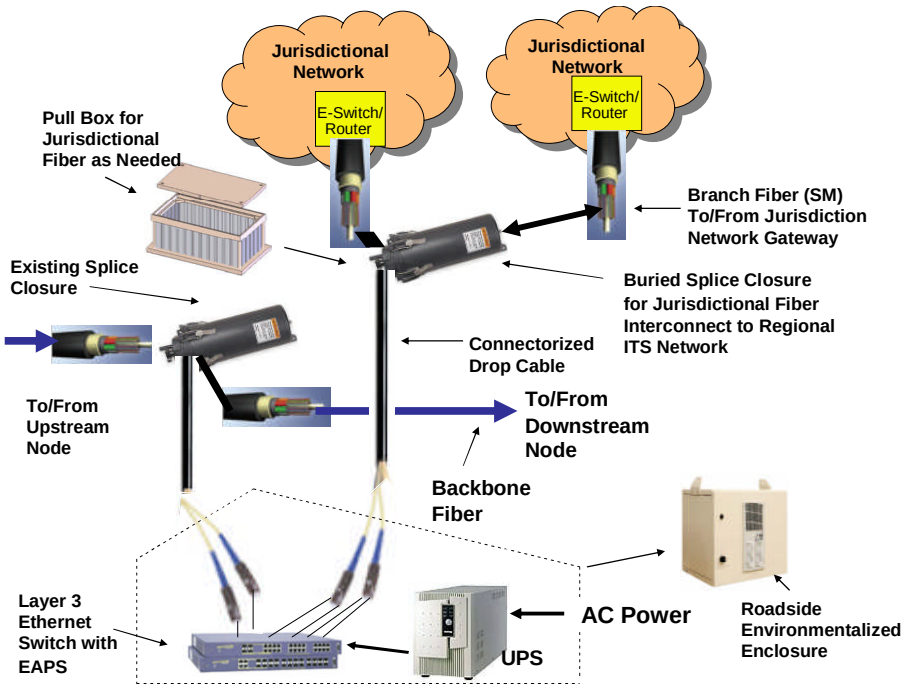


Table 1.5-1 presents opinion of probable deployment cost for a Regional ITS Network backbone node installed in an existing node building and table 1.5-2 presents the similar planning cost for a roadside node installed in a secure, environmentalized cabinet. Table 1.5-3 summarizes the construction cost for nodes. Tables 1.5-4 summarizes cost projections of $10.53 million for the regional network based on stated assumptions. Using jurisdictional interconnect mileage estimates 92.5 miles developed on past studies equates to 2.72 miles per jurisdictional interconnection (as compared to 2 miles). This will add an additional $1.9 million to the deployment cost estimate making it $12.43. Adding a 10% contingency provides $11.58 million (2 mile interconnects) or $13.7 million (2.72 mile interconnection per jurisdiction) for the opinion of probable deployment cost for the regional ITS network. These costs do not include cost of ADOT fiber, which is currently in or will be in the ADOT funding plan. As jurisdictions build out their ITS communications infrastructure, fiber should be planned to support the shortest point interconnect with the regional ITS network to accelerate interconnect schedule. It should be noted that an OC-192 SONET equivalent solution with bridge/routed interfaces would add an additional $4.0 million to the cost and this does not include any additional node buildings and upgrades of UPS as may be required to support SONET upgrade.

Table 1.5-1: Opinion of Probable Construction Cost for a Regional Network 10Gig-E Node Installed in an Existing Node Building

Unit	Quantity	Unit Cost $ Installed	Total Cost $ Installed
Ethernet Switch	1	$12,000	$12,000
Fiber Termination Panel, 12 Fibers	1	$800	$800
Buried Splice Closure for Jurisdictional Fiber	2	$720	$1440
Drop Cable, 100 ft. ea.	2	$100	$200
Fusion Splice Drop Cables	8 Splices	$180	$240
Pull Box for Buried Splice Closures	1	$1000	$1000
Jumper Cables/ Dual Connector	4	$100	$400
UPS for Ethernet Switch	1	$600	$600
Power Interconnect at Power Distribution Panel	1	$500	$500
Integrate, Provision, and Test	1 Job	$1,000	$1000
Total Planning Cost for Node Building Modification			$18,180

Table 1.5-2: Opinion of Probable Construction Cost for a Regional Network 10Gig-E Node Installed Roadside in an Environmental Cabinet

Unit	Quantity	Unit Cost $ Installed	Total Cost $ Installed
Ethernet Switch	1	$12,000	$12,000
Buried Splice Closure for Jurisdictional Fiber	2	$720	$1,440
Drop Cable, 100 ft. ea., Connectorized One End	3	$200	$600
Fusion Splice Drop Cables	8 Splices	$180	$240
Pull Box for Buried Splice Closures	1	$1,000	$1,000

Jumper Cables/ Dual Connector	4	$50	$200
UPS for Ethernet Switch	1	$600	$600
Power Interconnect at Power Distribution Panel	1	$3,000	$3,000
Environmentalized Cabinet on Slab	1	$15,000	$15,000
Integrate, Provision, and Test	1 Job	$1,200	$1,200
Total Planning Cost Roadside Node			$35,280

Table 1.5-3: Opinion of Probable Deployment Cost for Regional Network Nodes

Regional Network Node Cost Assuming Existing Node Building Use	Planning Number of Existing and New Node Buildings Supporting Regional Network Deployment	Planning Number of New, Roadside Nodes Supporting Regional Network Deployment	Unit Cost of Node Building Supporting the Regional Network Node	Unit Cost of Roadside Node Building Supporting the Regional Network	Opinion of Deployment Planning Cost (Node Only)
	14	18	$18,180	$35,280	$890,000

Table 1.5-4: Opinion of Probable Design and Construct Cost for an Ethernet Regional ITS Network Utilizing ADOT Fiber and Conduit, Node Buildings (Where Applicable) and Assuming Average of Two Miles to Jurisdictional Network Gateway

Other Cost Elements	Assumptions	Planning Cost $ (FY-07)
Regional Gateway Nodes	See Table 4.4-3	$890,000
Fiber to Jurisdictional Gateway	2 Miles Average per Jurisdiction at Cost of $106K/Mi.* for fiber and Conduit Installed and 20 Pull Boxes at $1000 ea. Installed. Assume 34 Interconnects ($178,400 ea)	$7.9 Million
Network Management	Maintenance Work Station and Network Management Software at two Locations. $10K/Loc.	$20,000
Integrated Network Testing	$128,000	$128,000
Spares	10% of Materials	$90,000
Mobilization		$100,000
Construction Cost		$9.13 Million
Additional Cost		
Design of the Network		$1.0 Million
Construction Oversight		$400,000
Subtotal Additional		$1.4 Million
Total Design and Construct		**$10.53 Million**

Ref. National Cost of Metro ITS Infrastructure, July 2006, USDOT

Some jurisdictions must be responsible for the management and maintenance of the jurisdictional network. This should be logically ADOT, MCDOT, or MAG. A primary and secondary network management point should be established with the secondary point not being capable of network provisioning changes unless

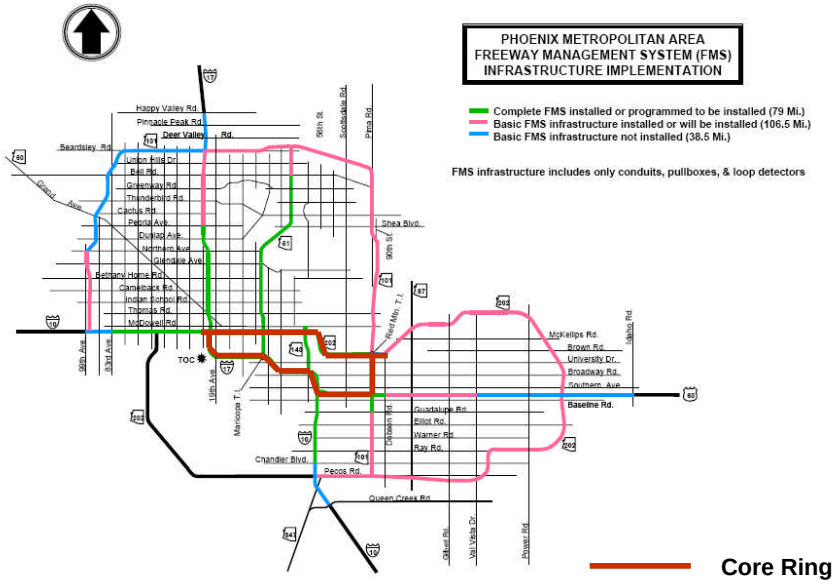
the primary network management point has failed. The secondary point will be capable of monitoring failures and monitoring performance status of the network and assuming all functions upon failure of the primary network management subsystem. ADOT is set up for support of a network over a wide area and is perhaps most suitable to assume network management responsibility. Suppliers of Ethernet Network equipment will provide service contracts and will provide network monitoring, management, and failure repair for approximately $125,000 per year. This includes the maintenance of electronics and the isolation of fiber cuts, but not the repair of fiber cuts. ADOT should be responsible for maintenance of their fiber. Jurisdictional interconnect fiber repair (2.72 miles on average/jurisdiction) would be accomplished by a fiber construction/repair contractor. For planning purposes, fiber repair is assumed to be $75K/year for a total maintenance cost of $200K/year.

1.6 Deployment Schedule

Currently deployed ADOT fiber topology supports the near term possibility of deploying the core ring for the regional ITS network. This is shown in figure 1.6-1. Figure 1.6-2 illustrates the additions of folded rings to accommodate jurisdictional interconnects. Early deployment by ADOT of fiber NE on 101 and West on 202 from Loop 101 would be required as well as extension of fiber on I-10 West of Loop 202 to accommodate Avondale and Goodyear jurisdictional interconnects. Also, fiber deployment along Loop 202 to the North, West of the I-10 intersection would be required to support jurisdictional interconnections clustered around Surprise. This will be considered as a Phase 2 deployment as appropriate based on ADOT's fiber deployment. Furthermore, a segment of fiber along Loop 202 supporting interconnection of Chandler and Gilbert would be required.

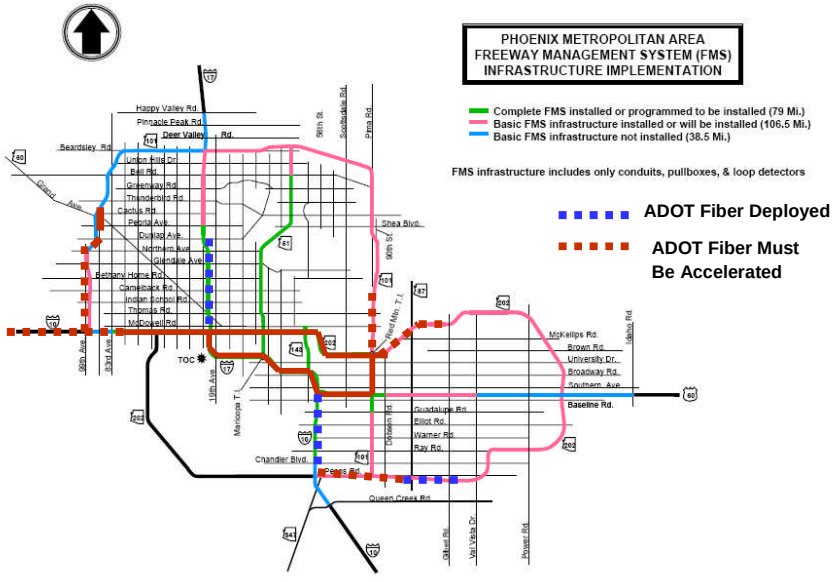
Phase 3 deployments would be as shown in figure 1.6-3 or figure 1.6-4. These figures represent the formation of the NW and East subnet rings, each supporting 10Gig-E operations. Jurisdictional fiber interconnects from jurisdictional network gateways to the nearest regional ITS network communications node would be scheduled in conjunction with node interconnect completions.

Figure 1.6-1: Core Ring Deployment



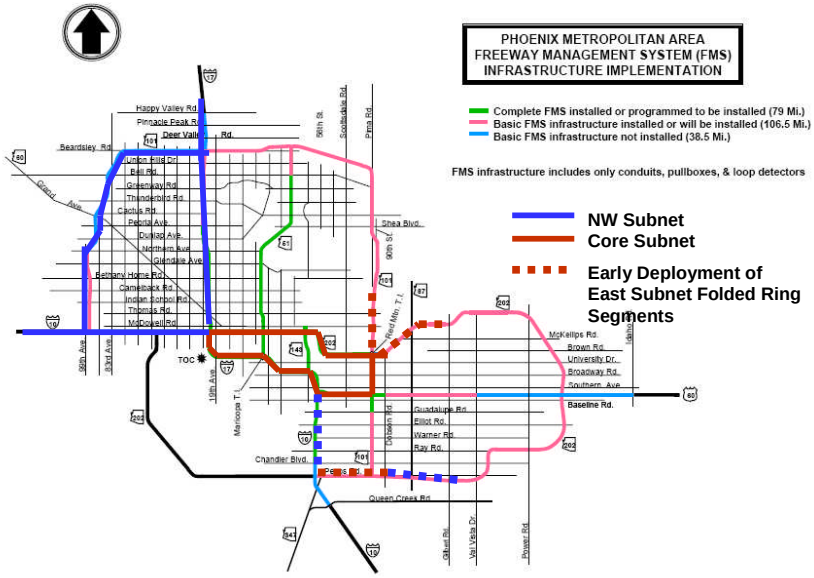
Core 10 Gig-E Optical Ring

Figure 1.6-2: Core Ring Folded Extensions



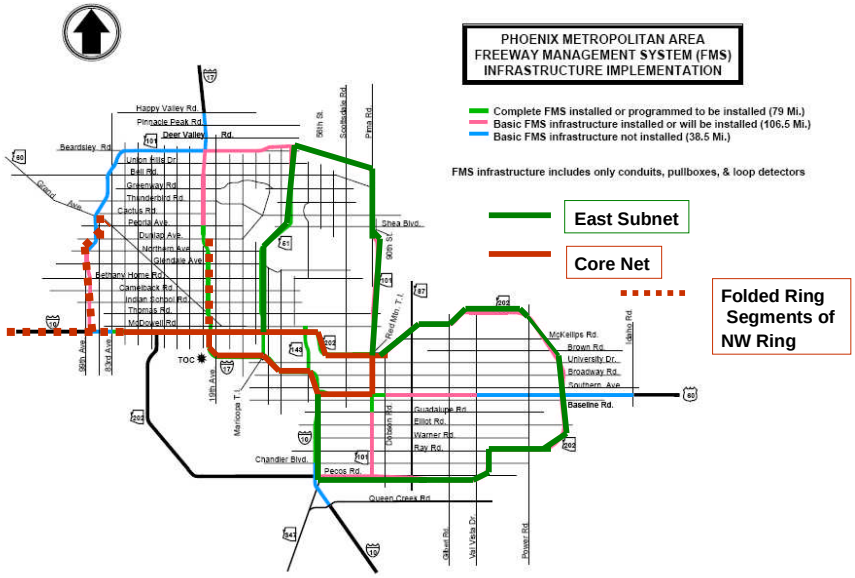
Core 10 Gig-E Optical Ring with Folded Extensions

Figure 1.6-3: Possible Phase 3 Subnet



North West 10Gig-E Ring Forming Subnet

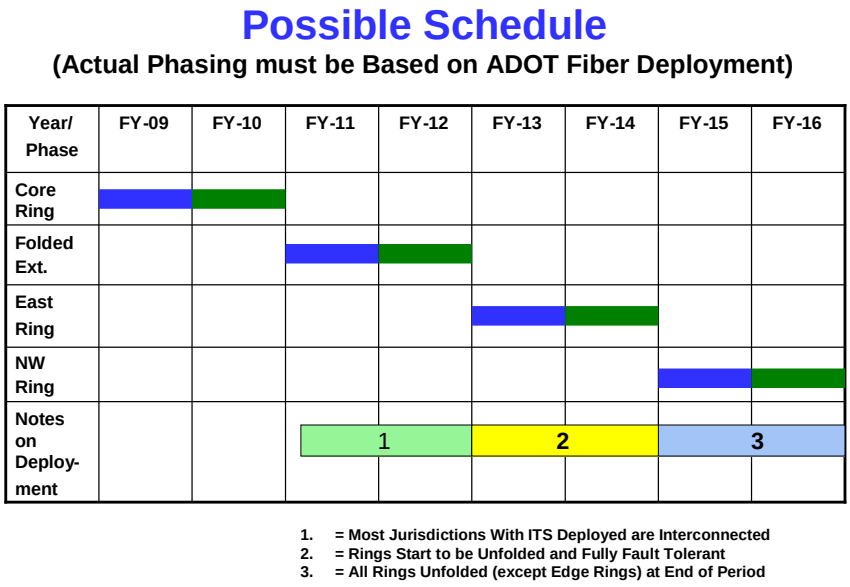
Figure 1.6-4: East Subnet Deployment

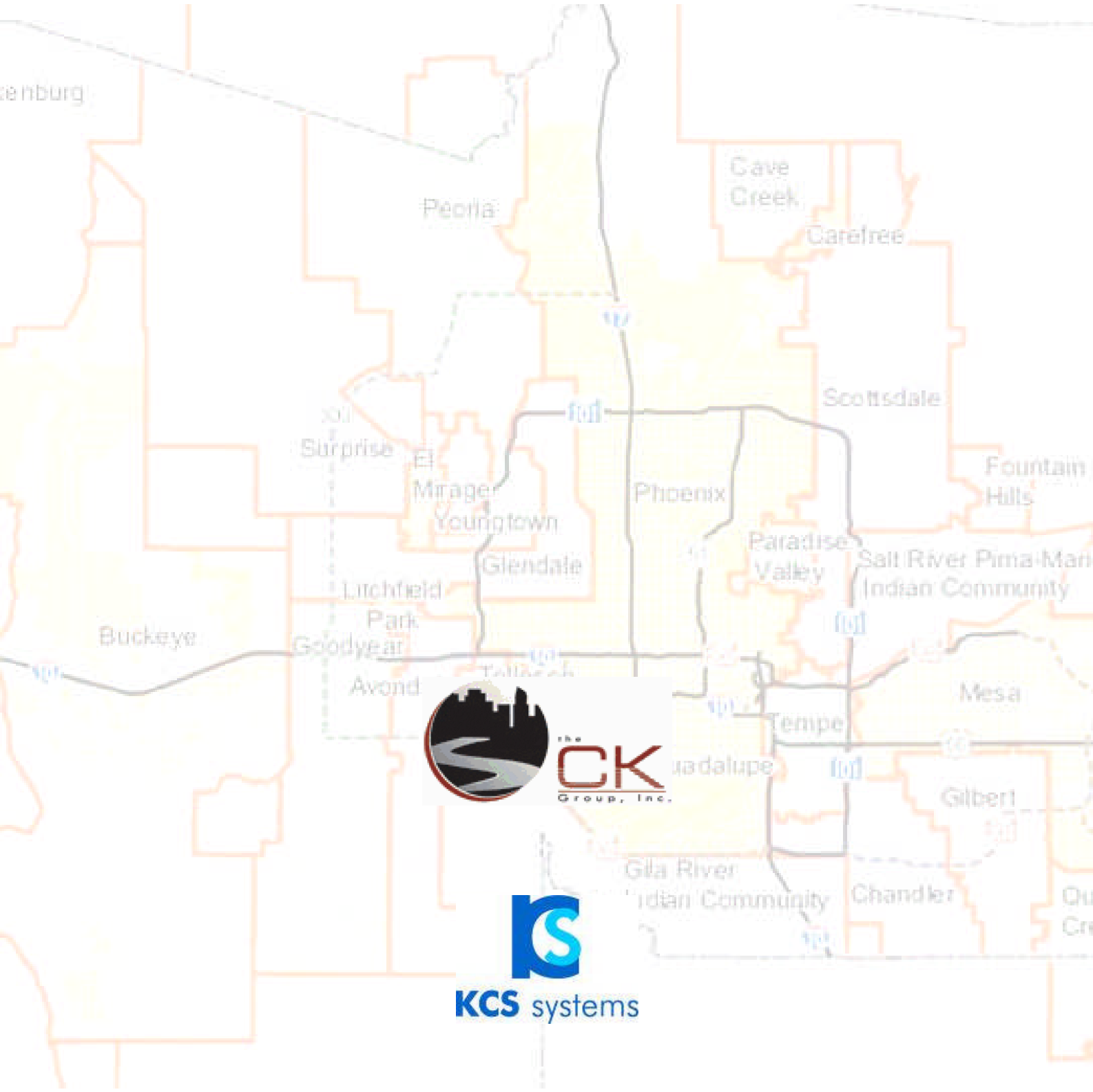


10Gig-E Optical Ring Forming East Subnet

Figure 1.6-5 presents a possible schedule for deployment. The core ring would be the first to be implemented followed by folded extensions to interconnect jurisdictions that have ITS devices deployed and a TMC to manage the devices. Folded rings would then be unfolded forming the NW and East rings. This schedule can be accelerated; however must be in accordance with ADOT deployment of fiber. Jurisdictional interconnect deployment should be planned to coincide with the construction of the interconnecting ring.

Figure 1.6-5: Planning Schedule for the Regional ITS Network

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Scottsdale
Surprise
El Mirage
Youngtown
Phoenix
Fountain Hills
Glendale
Paradise Valley
Salt River Pima-Mari
Indian Community
Litchfield Park
Buckeye
Goodyear
Avond
Tempe
Mesa
Gilbert
Gila River
Chandler
the CK Group, Inc.
KCS systems